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## Phonological Disorders in Children? Design and user experience evaluation of a mobile serious game approach

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### Abstract

This paper presents the concept and the user evaluation study of the first Super-Fon's prototype, which is a mobile health app with a serious game approach for Android Tablets. It was developed with the main goal of working as a complement to the therapeutic intervention in phonological disorders in children between 3 and 8 years old. The app comprises a range of activities, grouped into levels, presenting a therapeutic intervention that follows the Metaphon methodology. The serious game dimension was added to better engage children in its use. The paper presents a user study conducted with two groups of children, without and with the phonological disorders. The first one worked as a control group to better help finding out if the prototype is well designed and provides a positive user experience to be well received by the children, engaging them, despite their condition. The results of the study were very positive and promising.

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### 1. Introduction and Background

The use of computer technologies in Speech Language Therapy (SLT) is becoming common. Moreover, positive results can be found in the treatment of phonological disorders in children<sup>1</sup>. On the other hand, in the last decade, we witnessed an explosion in the use of mobile technology among young children<sup>2</sup>. Mobile health (mHealth) apps are tools that support patient-centered models of healthcare by enhancing patient involvement and self-management capabilities<sup>3</sup>. Moreover, intervention with children should follow therapeutic strategies based on the use of pictures

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and games in general, working in a playful manner, in order to make it, besides stimulating, interesting to the children<sup>1</sup>. Serious games based therapy (theragames) is currently gaining a lot of interest by the healthcare community<sup>4</sup>. These solutions make use of game mechanics and design techniques to improve the user experience and user engagement<sup>5</sup>.

The project Super-Fon<sup>6</sup> was designed to complement the therapeutic intervention in phonological disorders in children between 3 and 8 years old. Super-Fon is a mHealth app with a serious game approach based on the Metaphon therapy<sup>7</sup>. A metaphonological approach develop and use children's phonological awareness to make changes in speech. Metaphon is based on metalinguistic tasks, such as homophony confrontation. This methodology is composed of two phases. Phase one allows children to play and learn about sound properties, which enables children to transfer that knowledge to a real communicative environment<sup>8</sup>. This phase presents four different levels: 1-Concept; 2-Sound; 3-Phoneme; 4-Word. Children can only go to the next level when the previous one is acquired<sup>7</sup>. The main objective of phase two is to develop metaphonological and metacommunicative awareness in the child, presenting three main objectives: 1) transfer the metaphonological knowledge obtained during therapy in the previous phase to a more communicative situation; 2) build up metacommunicative awareness; and 3) develop metaphonological awareness so that the child can alter, or repair, output in order to convey meaning. The first prototype of Super-Fon implements Metaphon's phase 1 for now.

There are a few interesting related projects<sup>9,10,11</sup>, but none of them follows the Metaphon methodology. For instance, the Phonological Processes app<sup>12</sup> was also created for children ages 4 and up, but it implements a linguistic approach by engaging users in minimal pair contrast therapy. The minimal pair approach to phonological remediation teaches children the function of sounds, emphasizing that changing sounds changes the meaning of a word<sup>13</sup>. Minimal contrast therapy targets pairs of words that differ only by one sound. Finally, it is worth noting that Articula<sup>14</sup> is an app for iPad which is the only solution found for the European Portuguese, aiming to support the training of correct articulation of consonantal phonemes. It includes game mechanics, but it does not present a story and its gameplay.

Besides summarizing the concept behind the Super-Fon approach, this paper is mainly focused on a user study conducted with children to find out if the first Super-Fon's prototype is well received by its potential end users. It was important to find out if it can provide a positive user experience towards its use as a real tool to engage children in therapy. Preliminary results show the promising prospects a mobile serious game solution holds in such contexts. Additionally, the study was used to select a group of children to integrate a Participatory Design (PD)<sup>15</sup> process for the rest of the development.

## 2. Super-Fon

The Super-Fon project aims to address the difficulties in self-management of the phonological disorders, including poor rates of adherence to therapy guidelines, in order to improve the awareness of children and their parents regarding the disorder they are facing. The main goal of the Super-Fon app is to increase children, their parents, and relatives, involvement in the therapy, engaging them to enhance control over the path of their disorder. This mHealth app should be used mainly in the scope of a speech therapy program with the supervision of a therapist, which is the user responsible for configuring the game according to each child's individual characteristics.

The prototype of Super-Fon was developed for Android Tablets and using the Portuguese language<sup>6</sup>. Summarizing its rationale and gameplay, the activities (real gaming moments) are organized according to the four levels of Metaphon's phase one: concept, sound, phoneme, and word. When a child responds to an activity, s/he will hear a positive or negative message along with a small animation according to her/his performance. In the case of success, the user will earn a digital coin, which can be used to buy stickers. Each sticker has a value, so the child has to earn as many coins as s/he can. A funny and engaging element in the game is the fact that the stickers can be printed in back and white in order to be colored by the child, who also collects them. These represent characters of the story that are also used to illustrate the activities (see Fig. 1). A "purchased" sticker fills a gap in the digital stickers' booklet, which was designed to stimulate the child to play the game and hit as many activities as possible, even after finishing a level. The gameplay requires a certain percentage of activities answered correctly in order to allow the user to go to the next level. More on Super-Fon can be found in <sup>6</sup>.

### 3. User Experience Evaluation

The Super-Fon R&D team followed an iterative design process, so the concept, gameplay and interfaces have been tested by different users at different times and for different purposes. A preliminary user study was conducted to validate the Super-Fon's concept<sup>6</sup>. Then, a first test round with therapists started as soon as the team got the first fully functional prototype, being mainly focused on the Metaphon methodology implementation, main usability aspects, and the overall effect of gameplay. The results were positive and a few major issues were identified and corrected. A second test round, this time with children, is described as follows.

#### 3.1. Participants and Design

The user tests were conducted with two different groups of participants:

- G1) 28 children (20 male; 8 female), aged 4 to 7 (M (Mean) = 5.8; SD (Standard Deviation) = 0.8), with normal language development;
- G2) 7 children (3 male; 4 female), aged 5 to 9 (M = 6.6; SD = 1.4), diagnosed with phonological disorders.

89% of G1's and 100% of G2's participants use Tablets. Participants of G1 were easily selected from schools, while participants of G2 were harder to find and invite due to their specificity. A smaller percentage of the population has phonological disorders and we had to get the ones that were already diagnosed with a type of disorder suited to our methodology. Moreover, the articulation between our institution's services, the participants' therapists and their entities was not simple. Thus, G1 was used also as a control group to reinforce the evaluation and clarify to which point the G2's results were closely dependent on the participants' impairment.

The tests included performing tasks and post-test questionnaires verbally posed by our team's therapists to the participants. The team measured the following dimensions in two parts (both using a 5-point Likert-type scale, ranging from strongly disagree (1) to strongly agree (5)):

- P1) usability of the app, using the Portuguese version of the System Usability Scale (SUS)<sup>16</sup>;
- P2) user satisfaction of essential characteristics.

Two different focus groups (FC) were conducted with representative participants of both G1 and G2 to start involving them in the design and evaluation processes of the development, following a participatory design strategy. Participants of both FC suggested that Super-Fon could present more colorful elements and provide more stickers to buy. Children from G2 especially wanted to have more characters. Fig. 1 illustrates how the focus groups' brainstorming driven the improvement of the characters design in relation to the previous work presented in <sup>6</sup>.

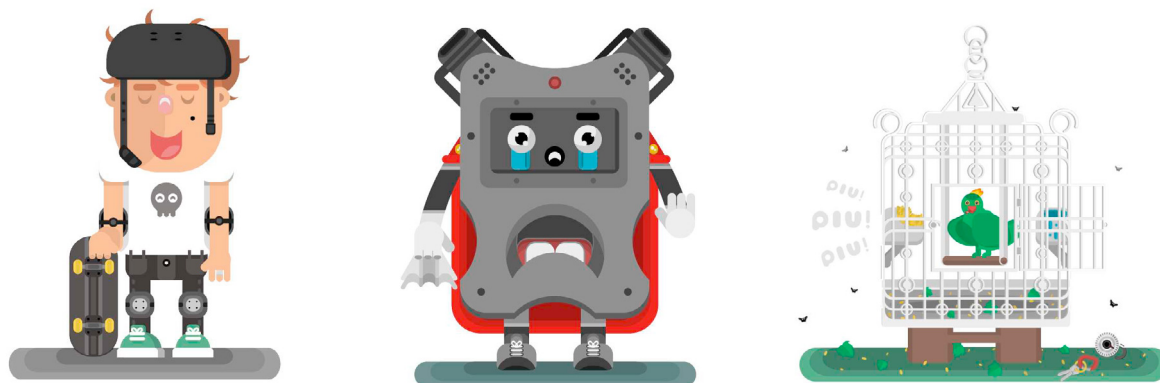


Fig. 1. Characters' new design after the tests and focus groups' brainstorming: Fon, Super-Fon and Bird in cage used in an activity.

### 3.2. Findings

Regarding the tests' P1 based on SUS, participants of G1 would like to use Super-Fon frequently (Q1:  $M = 4.75$ ;  $SD = 0.70$ ), not finding it unnecessarily complex (Q2:  $M = 2.04$ ;  $SD = 1.07$ ), and considering it as being easy to use (Q3:  $M = 4.18$ ;  $SD = 1.02$ ). Moreover, these participants were uncertain if they would need the support of an adult or therapist to be able to use Super-Fon (Q4:  $M = 2.43$ ;  $SD = 1.13$ ), however referring that the various functions and gameplay were well integrated (making sense) (Q5:  $M = 4.29$ ;  $SD = 0.71$ ), and there was not too much inconsistency (errors for them) in Super-Fon (Q6:  $M = 1.61$ ;  $SD = 0.74$ ). They thought, although with some doubts, their friends would learn to use the app very quickly (Q7:  $M = 3.89$ ;  $SD = 1.23$ ), not having found it very cumbersome to use (Q8:  $M = 1.75$ ;  $SD = 1.08$ ). Participants reported they felt very confident using Super-Fon (Q9:  $M = 4.54$ ;  $SD = 0.58$ ), although the result of Q10 (needed to learn a lot of things before they could get going with it) was unsatisfactory ( $M = 2.61$ ;  $SD = 1.5$ ). Overall, for a first prototype, the results are very positive (Fig. 2) representing a SUS value of 71.5, which means the Super-Fon's usability is acceptable and very near to a good ranking.

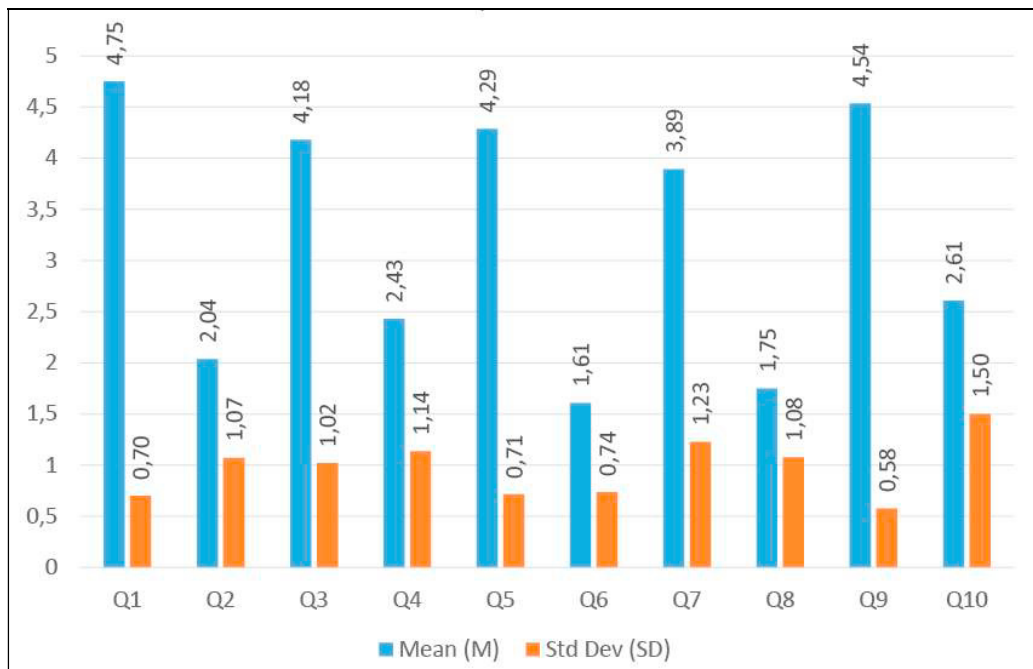


Fig. 2. G1's feedback to the questions of SUS in tests' P1.

On the other hand, Fig. 3 shows that G2 gave less positive responses to the SUS questions of P1. The more problematic issues are related to Q2, Q4 and Q10, meaning that participants thought Super-Fon is really complex, and they would need support and to learn a lot of things before they could use it. The result of Q7 corroborates it since they thought their friends would have difficulties in learning it quickly. The SUS value of 63.0 means the Super-Fon's usability is barely acceptable for G2, with an OK ranking.

The overall (G1 and G2) results of SUS can be justified by the need to improve certain aspects of Super-Fon, especially felt by children in G2, but may also be due to a certain difficulty presented by the children to answer some of the questions that may be somewhat more abstract for them.

The questions of the tests' P2 were grouped into 5 dimensions of analysis:

- d1) game concept;
- d2) instruction;

- d3) functionality;
- d4) design;
- d5) motivation.

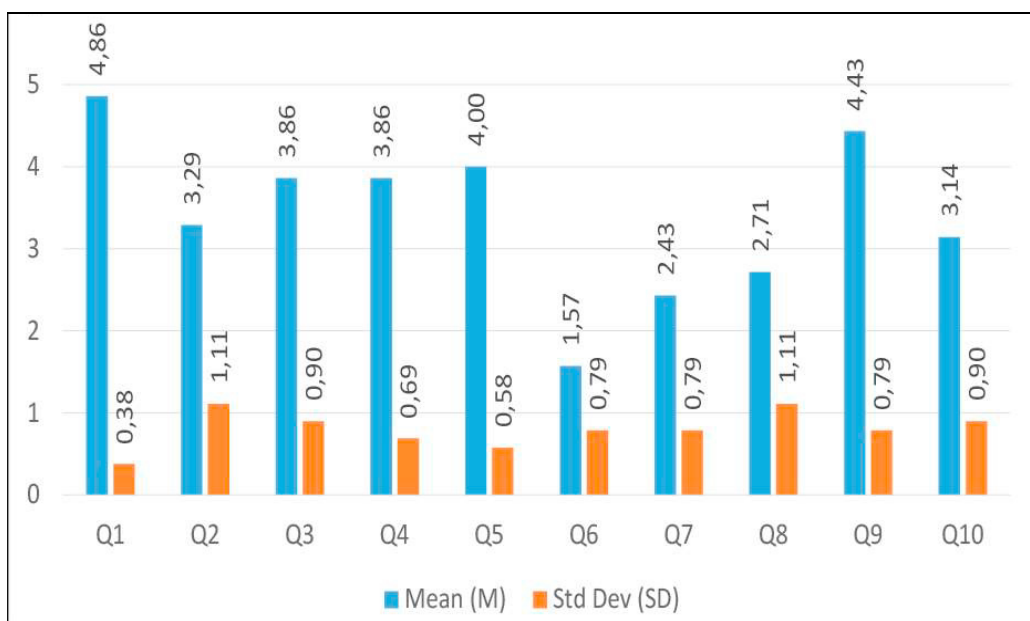


Fig. 3. G2's feedback to the questions of SUS in tests' P1.

Fig. 4 shows that the results are very positive, but aspects related to functionality should be improved, which is in line with the worst results extracted from P1.



Fig. 4. Participants' feedback to the questions of tests' P2.

## 4. Conclusions

The evaluation results are positive and according to the expectations. These preliminary results show the promising prospects Super-Fon holds in such a context like the one it addresses.

We will proceed with new tests very briefly, using an improved version of the prototype. The tests will maintain the focus groups' participants and G2 will have a higher number of participants. It will be important to clarify the reason why G2's results are worse since these children are the focus of the project. Super-Fon will be tested in an effort to evaluate and refine the process of positive behavior change and maintenance over the long term in these children.

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